No. IV.

Miſcellaneous Experiments relating to the Doctrine of Phlogiſton. By Dr. JOSEPH PRIESTLEY.

1. IT has been ſaid that the fixed air which I get by heating iron in dephlogiſticated air, comes from the plumbago contained in the iron, and that when it is found after the union of inflammable and dephlogiſticated air, it was from plumbago diſſolved in the inflammable air. But beſides that there is no evidence of inflammable air containing any plumbago (ſince when iron is diſſolved in any acid the plumbago is left behind) the fixed air contained in this ſubſtance is very inconſiderable, the bulk of the air into which it may be reſolved being inflammable.

From 6 dwts. of the fineſt plumbago from an iron furnace, in the form of a light powder, I got in a glazed earthen tube 40 ounce meaſures of air, one-twelfth part only of which was fixed air, and the reſt inflammable, burning with a blue flame. Then ſending ſteam through it, I got 240 ounce meaſures more, the whole of which was inflammable, of the pureſt kind, exactly reſembling that from iron by the acid of vitriol. The plumbago was concreted into one maſs, reſembling a hard cinder, and weighed $2\frac{1}{2}$ dwts.

Another experiment on plumbago I ſhall mention in this place. Melting one dwt. of it with a burning lens, it threw out ſparks, like caſt iron treated in the ſame manner, but not quite ſo much; after which it was reduced to a ſlag, like finery cinder, weighing 4 grains leſs than it had done. I repeated the experiment with the ſame reſult.

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2. The experiments on the revival of precipitate per ſe in inflammable air being differently reported by different experimenters, and being ſometimes attended with hazard, I ſhall add the following, which were made ſeveral years ago, to thoſe which I have made and repeated ſince.

In 9 ounce meaſures of inflammable air from malleable iron and water I revived part of the precipitate ſent me by Mr. Berthollet, which I had found to contain no fixed air, till not more than one-fourth of the air remained unabſorbed; on examination, I found about one-twentieth part of it fixed air; but mixing nitrous air with it, it appeared that the air diſlodged from the precipitate had not united with the inflammable air; for the ſtandard of equal meaſures of them was 1.71. After the proceſs I miſſed 18 grains of the precipitate. But there are ſeveral cauſes of loſs in this caſe, beſides the quantity of air expelled from the ſubſtance.

In 5.5 ounce meaſures of the ſame inflammable air I revived ſome of the ſame precipitate till it was reduced to 0.77 ounce meaſures. Of this one-ſixth part was fixed air, and the reſiduum of the ſtandard of 1.6. It exploded at once when the flame of a candle was preſented to it.

3. As pyrophorus imbibes pure air when it is expoſed to atmoſpherical air, leaving nothing but phlogiſticated air, (in which it reſembles a mixture of iron filings and ſulphur, which alſo makes a pyrophorus,) the fixed air expelled from it afterwards muſt have been formed by the union of the pure air imbibed by it and the phlogiſton contained in itſelf.

From a quantity of old and ſpoiled pyrophorus I got 180 ounce meaſures of air, of the firſt part of which one half was fixed air, and the reſt phlogiſticated. At the laſt, the one half was fixed air, and the reſt was inflam-

inflammable. In another experiment of this kind I found ſeven-tenths of the air fixed, and the reſt inflammable.

The fixed air that is expelled from lime which has been long expoſed to the atmoſphere cannot have any other origin than the pure air that it has imbibed and ſome phlogiſton which it derived from the fire; for the air to which it is expoſed is always ſomething leſs pure than it was before.

From 15 dwts. of fallen lime I got 45 ounce meaſures of fixed air, and 25 inflammable from the gun barrel in which the experiment was made. Whether quicklime has been expoſed to the atmoſphere, ſo as to become what is called *fallen lime*, or has been ſaturated with water, they come in time to be of the ſame weight, and to have the ſame properties; the former continually gaining weight, and the latter loſing it.

From 15 dwts. of lime ſaturated with water, and then expoſed to the atmoſphere, I got 55 ounce meaſures of fixed air.

4. If any metal be calcined in common air over lime water, a very thick ſcum will be formed on its ſurface, and much of the air will be imbibed by the calx that is formed. I have recited the reſult of this proceſs with ſeveral of the metals, and I ſhall now obſerve that I had the ſame reſult with platina, ſilver, and gold. In the experiment with platina 33 ounce meaſures of air were reduced to $26\frac{1}{2}$, of the ſtandard of 1.75.

5. That phlogiſticated air is ſometimes formed by the union of dephlogiſticated air and phlogiſton is as clearly proved by experiment as that fixed air is formed from the ſame elements. One proof of this is that common air can never be diminiſhed ſo much by the pureſt dephlogiſticated air as it may be by nitrous air, the reſiduum in both the caſes being alike phlogiſticated air. I could

could not by any mixture of dephlogiſticated and inflammable air, fired by an electric ſpark, reduce it to leſs than 2.5; whereas by nitrous air the ſame dephlogiſticated air was diminiſhed to 0.04; ſo that there muſt have been a production of phlogiſticated air when the inflammable air was uſed.

If after any diminutions of common air by phlogiſtic proceſſes more phlogiſticated air is found in ſome of them than there is in others, the additional quantity muſt have been formed in the proceſs; and that there is a great variety in theſe reſults I have obſerved before.

Heating fine needles in common air over mercury till, after its greateſt diminution, it was increaſed to its original bulk, I found that it had nothing ſenſibly inflammable in it, but was wholly phlogiſticated; whereas the addition of one-fourth of inflammable air to three-fourths of phlogiſticated air was eaſily diſtinguiſhable by the flame of a candle. Fixed air will be produced in this proceſs if it be made over lime water, but not with certainty in any other circumſtances.

When ſubſtances that diminiſh air, and leave it phlogiſticated, emit inflammable air before and after the proceſs, it is reaſonable to conclude that they did the ſame during the proceſs; and ſince nothing inflammable is found in the air after it, that it united with the pure part of the air to which it was expoſed, and by that union formed part of the phlogiſticated air; ſo that leſs of this kind of air exiſted in the atmoſphere than has generally been ſuppoſed. This I have obſerved to be the caſe with a mixture of iron filings and ſulphur. It was the ſame with iron that had been partially diſſolved in vitriolic acid. After diminiſhing a quantity of air I immerſed it in mercury, and it gave out a ſmall quantity of inflammable air.

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I have recited one caſe of phlogiſticated air being formed by expoſing ruſted iron to inflammable air, which muſt have been formed by the oxygen in the ruſt and the phlogiſton in the air. There is, however, much uncertainty in this reſult, depending on circumſtances which I have not been able to aſcertain. But one clear caſe of the kind is ſufficient proof of the hypotheſis, and I have met with ſeveral.

On the 15th of Auguſt 1799 I examined a quantity of inflammable air which had been confined by mercury with dry iron ruſted in nitrous acid from the 18th of March 1798, and found nothing inflammable in it, though there was no apparent change in the colour of the iron. This was alſo the caſe of another quantity of the ſame kind of air which had been confined in the ſame manner from the 14th of July. At the ſame time, however, another quantity of inflammable air that had been confined the ſame time, and in the ſame manner, with iron ruſted in vitriolic acid was not much changed, though the iron was become black.

Since pure nitrous air wholly vaniſhes when it unites with pure dephlogiſticated air, the phlogiſticated air that is found after heating iron in it muſt have been formed from ſome oxygen contained in the nitrous air and phlogiſton from the iron. After heating turnings of caſt iron in $5\frac{1}{2}$ ounce meaſures of nitrous air from mercury it was reduced to $3\frac{1}{2}$ ounce meaſures, and by waſhing in water to $2\frac{1}{2}$, one ounce meaſure having been fixed air. But when I heated malleable iron in 60 ounce meaſures of the ſame nitrous air it was reduced to 24 ounce meaſures, all phlogiſticated. When I continued this proceſs beyond the point of greateſt diminution, the air produced was inflammable.

Since water contains but a ſmall quantity of air in proportion to its bulk, and generally conſiderably purer than that

that of the atmoſphere, the phlogiſticated air that is found by heating ſteam in a copper veſſel muſt have been formed from phlogiſton in the copper, and the pure part of the air contained in the water; and whenever I have heated water in this manner and have kept it a conſiderable time in the form of ſteam, I have found a quantity of air completely phlogiſticated, and the longer I kept it in this ſtate the more of this air I found.

I have obſerved that when metals are calcined in common air over water, the air is always diminiſhed, and if it be done over lime water, fixed air is produced. If the calcination be continued after the greateſt diminution of the air, it will be increaſed by an addition of inflammable air. If this inflammable air came from the decompoſition of the water, the water over which the proceſs was made would either be acid, or contain pure air, but this is never the caſe. This water is both free from all acidity, and gives out air leſs pure than that of the atmoſphere. Alſo the air confined in the ſame phial with it is leſs pure than that of the atmoſphere. If the oxygen of the water entered into the calx that is formed, hydrogen, or inflammable air, ought, according to the new theory, to be formed, which it is not.

Alſo air from water in which mercury has been agitated is conſiderably worſe than common air. A candle went out in it. Had the black powder which is formed in this proceſs been owing to the decompoſition of the water, ſince this powder is mercury ſuper-phlogiſticated, the remaining water would have been in a ſtate of oxygenation; and therefore the air expoſed to it would have been purer than that of the atmoſphere.

It is ſaid that metals become calces by imbibing oxygen; but no oxygen has yet been diſcovered in finery cinder, and very little, if any, in flowers of zinc. If minium or red precipitate, be diſſolved in marine acid, none of the

dephlogiſticated air which theſe ſubſtances contain is then extricated; but if the ſolutions be evaporated, and the dry reſiduum be heated by a burning lens, the pure air is evolved. For the common air in which they are heated receives an addition of pure air. But the reverſe is the caſe when the ſolutions of finery cinder or flowers of zinc are treated in the ſame manner.

I heated a ſolution of the pureſt flowers of zinc in marine acid in common air, and obſerved that it emitted a denſe white vapour for about an hour after it was evaporated to dryneſs. The air was but little diminiſhed, but worſe than common air, in the proportion of 1.45 to 1.35.

I have obſerved that common air which has been expoſed to hot charcoal is both diminiſhed and phlogiſticated, but that the air which by immerſion in water comes out of this charcoal is likewiſe phlogiſticated. This proves the generation of phlogiſticated air in the proceſs. The water over which this proceſs is made alſo gives out air leſs pure than that of the atmoſphere.

Charcoal that had been expoſed in common air under a receiver ſome days, did not, when immerſed in water, give out more than half as much air as charcoal heated and put into water immediately after it was cold. Both being placed near the fire, ſtill immerſed in water, gave out more air, but in the ſame proportion. Alſo, ſtanding in this ſituation a long time made no difference in this caſe.

6. That finery cinder contains nothing but water and calx of iron, I think I have ſufficiently proved by ſeveral obſervations, eſpecially by its enabling hot charcoal to give out the ſame kind of air that water will do. I had a ſimilar reſult with *terra ponderoſa aerata*, which gives no fixed air with mere heat, but does it when red hot by means of water.

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I mixed a quantity of this ſubſtance pounded with pounded finery cinder; and putting it into a gun barrel, got from it fixed air as copiouſly as if a ſtream of water had paſſed over it. There was a conſiderable reſiduum, which was inflammable air from the iron.

7. Dr. Woodhouſe obſerves that if the manganeze be heated in inflammable air, and much of the air diſappear, the metal is not revived. But not only may the calces of metals imbibe much phlogiſton before their complete revival in a metallic form, but other ſubſtances alſo appear to do the ſame. After heating calcined alum in inflammable air, it became black, and the air was diminiſhed one-fifth. The inſide of the veſſel in which the proceſs was made had alſo a black coating. And brick, which contains iron ore, becomes black in the ſame circumſtances; but it is not even attracted by a magnet afterwards. Pounded flint glaſs becomes black, and abſorbs inflammable air, when it is melted in it with a burning lens; but no lead is formed.

8. I have obſerved that when a mixture of dephlogiſticated and inflammable air is exploded, *acid* is produced if there be any exceſs of the dephlogiſticated air, but only *water with phlogiſticated air* if there be any exceſs of the inflammable air. Theſe proportions I endeavoured to aſcertain, and I found that acid is formed when 100 meaſures of inflammable air are united to 51 meaſures of dephlogiſticated air; but that only water was produced when 100 meaſures of inflammable air were united to 47 meaſures of dephlogiſticated air.